Texture Mapping
Reference Material
The slides have used/adapted material from the following references:

1. Advanced Animation and Rendering Techniques by Watt and Watt
2. Course (CS5620) slides by Prof Kavita Bala, UNC
Texture Mapping
Texture Mapping

How do we model the surface details?

**Explicit detailed geometry modeling**
Expensive and may be unnecessary

**Geometry and texture mapping**

Shape  Details
Mapping Function

Object: \((x(u,v), y(u,v), z(u,v))\)
Texture: \((s, t)\)
Texture Mapping

Mapping Function

Object : \((x(u,v), y(u,v), z(u,v))\)
Texture : \((s, t)\)

\[
\begin{align*}
u &= f(s, t) & s &= h(u, v) \\
v &= g(s, t) & t &= i(u, v)
\end{align*}
\]

linear mapping
\[
\begin{align*}
u &= As + B \\
v &= Ct + D
\end{align*}
\]
Texture Mapping

Mapping Function

Forward Mapping
Texture Mapping

Mapping Function

Texture

Inverse Mapping

Screen

Pixel
Texture Mapping

Mapping Function

- Map an image onto a surface
- Assume (u,v) coordinates in texture
- Mapping function \( M_{\text{tex}}^{-1}(x,y,z) \rightarrow (u,v) \) - Between object space and texture space
Texture Mapping

Examples

Simple patterns for skin, bricks, etc. May need to repeat texture (tiling)
Texture Mapping

Examples

Requires establishing correspondence between texture and surface points.
Texture Mapping

Mapping Function

Unprojected Latitude and Longitude
Cylinder Mapping

• Wrap texture along outside of cylinder, not top and bottom
  – This stops texture from being distorted

\[
\begin{align*}
\cos(\theta) &= \frac{x}{r} \\
\sin(\theta) &= \frac{y}{r}
\end{align*}
\]
Texture Mapping

Mapping Function
Texture Mapping

Mapping Function
Texture Mapping

Mapping Function

- box mapping
- cylindrical mapping
- planar mapping
Box Mapping Function
Texture Mapping

Cylinder Mapping Function
Texture Mapping

Sphere Mapping Function
Texture Mapping

This step can be done in many ways:

- Normal from intermediate surface
- Normal from object surface
- Use center of object
Texture Mapping

Mapping Function

Sample model from www.cyberware.com
Texture Mapping

Mapping Function

For each triangle in the model establish a corresponding region in the phototexture.

During rasterization interpolate the coordinate indices into the texture map.
Texture Mapping

Mapping Function

Constant Diffuse Color
Diffuse Texture Color
Texture used as Label
Texture used as Diffuse Color
Environment Mapping

Mapping Function

View Point

N

E

R

V

P

Object

Environment map on a sphere

Image of a teapot
Bump Mapping

Offset surface position

Displacement

\[ N(u,v) = \frac{P_u(u,v) \times P_v(u,v)}{|P_u(u,v) \times P_v(u,v)|} \]

\[ P'(u,v) = P(u,v) + h(u,v)N(u,v) \]

Perturb normal

\[ N'(u,v) = \frac{P'_u(u,v) \times P'_v(u,v)}{|P'_u(u,v) \times P'_v(u,v)|} \]

From Blinn 1978
Bump Mapping

\[
P = [x(u, v), y(u, v), z(u, v)]^T
\]

Initial point

\[
\vec{N} = \vec{P}_u \times \vec{P}_v
\]

Normal

\[
\vec{P}' = \vec{P} + B(u, v) \vec{N}
\]

Simulated elevated point after bump

\[
\vec{N}' \approx \vec{N} + B_u \vec{P}_u + B_v \vec{P}_v
\]

Variation of normal in \( u \) direction

\[
B_u = \frac{B(s - \Delta, t) - B(s + \Delta, t)}{2\Delta}
\]

\[
B_v = \frac{B(s, t - \Delta) - B(s, t + \Delta)}{2\Delta}
\]

Variation of normal in \( v \) direction
Bump Mapping

Bump mapping derivation

\( \tilde{P}' = \tilde{P} + \frac{B(u,v)\tilde{N}}{\|\tilde{N}\|} \)

\( \tilde{P}' = \tilde{P} + \frac{B_u\tilde{N}}{\|\tilde{N}\|} + \frac{B\tilde{N}}{\|\tilde{N}\|} \approx 0 \)

Assume \( B \) is very small...

\( \tilde{N}' = \tilde{P}'_u \times \tilde{P}'_v \)

\( \tilde{N}' \approx \tilde{P}_u \times \tilde{P}_v + \frac{B_u(\tilde{N} \times \tilde{P}_v)}{\|\tilde{N}\|} + \frac{B_v(\tilde{P}_u \times \tilde{N})}{\|\tilde{N}\|} + \frac{B_u B_v (\tilde{N} \times \tilde{N})}{\|\tilde{N}\|^2} \)

But \( \tilde{P}_u \times \tilde{P}_v = \tilde{N} \), \( \tilde{P}_u \times \tilde{N} = -\tilde{N} \times \tilde{P}_u \) and \( \tilde{N} \times \tilde{N} = 0 \) so

\( \tilde{N}' \approx \tilde{N} + \frac{B_u (\tilde{N} \times \tilde{P}_v)}{\|\tilde{N}\|} - \frac{B_v (\tilde{N} \times \tilde{P}_u)}{\|\tilde{N}\|} \)
Bump Mapping
Displacement Mapping